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AB The steel contains C .ltoreq.0.10, Si 2.0-9.0, Mn 0.05-6.0, Ni 1-24, Cr 6-28, Mo 0.2-4.0, Nb 0.03-2.0, Cu .LAMBDA.<4.0, W .ltoreq.4.0, Co .ltoreq.3.0, Al .ltoreq.1.0, TI .ltoreq.2.0, V .ltoreq.4.0, B .ltoreq.3.0, Ce .ltoreq.0.4, and La .ltoreq.0.4%. The parts of the steel which require hard hardness are heat treated by the process including operations 1-2-3 described below. The parts of the steel which do not require hard hardness are heat treated by the process including operations 1-3 or 1-2. (1) Heating to 900-1100.degree., rapid cooling, and aging at 600-700.degree.. (2) Heating to 950-1150.degree. and rapid cooling. (3) Aging at 400-600.degree.. The pptn. hardened steel has good mech. properties and is suitable for various machine parts.

Detailed description [067] pump member

for claims 2-3, 14-27, 29, 34

≤3.0 B
≤0.1 C
≤0.04 S
≤0.04 P } impurities
6-28 Cr
2-9 Si
0.2-4 Mo
≤4 W
≤4 V
0.03-2 Nb
≤3 Co
0.05-6 Mn

Fe

PATENT ABSTRACTS OF JAPAN

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(54) HEAT TREATMENT OF PRECIPITATION HARDENING TYPE HIGH SILICON STEEL PRODUCT

(57)Abstract:

PROBLEM TO BE SOLVED: To subject only the specific positions of precipitation hardening type high silicon steel parts of a specific component compsn. to a hardening treatment easily by subjecting the surface parts of these parts to partially different heat treatments.

SOLUTION: The surface layer parts where high hardness is needed of the precipitation hardening type high silicon steel pats consisting contg., by weight %, ≤0.10 C, 2.0 to 9.0 Si, 0.05 to 6.0 Mn, 1 to 24 Ni, 6 to 28 Cr, 0.2 to 4.0 Mo, 0.03 to 2.0 Nb, ≤4.0% Cu, ≤4.0 W, ≤3.0 Co, ≤1.0 Al ≤2.0 Ti, ≤4.0 V, ≤3.0 B and ≤0.4 rare earth elements and consisting of the balance Fe and inevitable impurities are heated and quantity at 900 to 110°C, are subjected to an aging treatment at 600 to 700°C, are heated and quenched at 950 to 1150°C and are subjected to the aging treatment at 400 to 600°C. On the other hand, the portions where the high hardness is not needed are heated and quenched at 600 to 700°C and subjected to the aging treatment at 900 to 1100°C and are then heated and quenched at 950 to 1150°C or are merely subjected to the aging treatment at 400 to 600°C.

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CLAIMS

[Claim(s)]
[Claim 1] At weight %, it is C. : 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel: 1-24%, Cr:6-28%, Mo:0.2-4.0 %, Nb : 0.03-2.0 %, less than [Cu:4.0%], W:4.0% or less, Co: The precipitation-hardening type high silicon steel to which less than [Ce:0.4%] and less than [La:0.4%] are contained less than [3.0%], less than [aluminum:1.0%], less than [Ti:2.0%], V:4.0% or less, and B:3.0% or less, and the remainder is characterized by the bird clapper from Fe and an unescapable impurity.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention is machine parts, such as a shaft of various devices, a roll, a roller, and bearing, and relates to the heat treatment method for manufacturing the parts a high silicon steel [type / precipitation-hardening / suitable as a material of the parts for which to have a tough nature and high degree of hardness, abrasion resistance, anticorrosion thermal resistance, etc. is needed], and above-mentioned.
[0002]
[Description of the Prior Art] Roll of various kinds of devices used for a chemical processing plant, an iron-manufacture plant, a building construction, etc. (roller) Shaft (shaft) Many [the parts of which tough nature, such as bearing and abrasion resistance are required simultaneously] In order to meet these demands, only a front face becomes a high degree of hardness, and the material to which a core part is rich in toughness is needed by suitable processing. As the art, a cementation process, nitriding, an induction hardening method, etc. are common knowledge, and various steel materials suitable for these processings are also developed.
[0003] In addition to tough nature and abrasion resistance, with the parts used under corrosive environment or an elevated temperature, corrosion resistance and thermal resistance are needed in many cases simultaneously. For example, tough nature and not only abrasion resistance but the outstanding corrosion resistance which bears a rainstorm or salt damage is required of the roller of the roller bearing which absorbs expansion and contraction of a bridge. Moreover, segment of the mold lower part of metaled continuous casting equipment (cast piece guide apparatus) In addition to high intensity and abrasion resistance, a high temperature strength and sufficient thermal resistance are also needed for the roll of the roller and rolling mill to constitute, and advanced corrosion resistance, such as acid resistance, is required of the parts for chemical processing plants.
[0004] As anticorrosion and a heat-resistant material, the austenitic stainless steel which makes Cr and nickel a major component is common. However, this stainless steel has intensity and a low degree of hardness, and they are unsuitable into a wear-resistant material of high intensity. Precipitation-hardening type steel is JIS as stainless steel which becomes high intensity and a high degree of hardness comparatively. Although standardized as SUS 630 and 631, this steel cannot respond to a severe service condition in recent years in cases, either. On the other hand, as hardening hardening type stainless steel, although SUS 440 and the 420J2 grade are known, it is the product. (for example, roller) When it hardens, the whole hardens to the core part of a product and there is a problem of losing toughness and becoming easy to break.
[0005] It is high intensity and quantity toughness, and excels also in corrosion resistance and thermal resistance, and there is "quantity silicon stainless steel" as steel equipped also with a high degree of hardness. This steel is patent 619,383rd. Number (JP,46-9536,B) It was patented by carrying out and the improvement steel is JP,57-17070,B further. (the 1,167,791st number of a patent) It is indicated. Such high silicon stainless steel is SHIRIKOROI. (registered trademark) It is called, and it is put in practical use by these people and has come to be used widely in recent years.
[0006] Above-mentioned SHIRIKOROI is steel of age-hardening nature which mainly has the two phase organization of an austenite and martensite. These people did patent application of the invention about the heat treatment previously. (refer to JP,7-97623,A) . The invention is invention which is a thing aiming at obtaining a deep case depth, and is comparatively characterized by three steps of heat treatment processes of a temper, solution-izing, and aging with short-time heat treatment.
[0007]

[Problem(s) to be Solved by the Invention] One of the purposes of this invention is to offer the new alloy which added improvement further, after employing the property of aforementioned SHIRIKOROI efficiently. Furthermore, another purpose is to offer the heat treatment method which gives the most desirable function to various parts made from SHIRIKOROI and its modified alloy, and the new heat treatment method that the parts which specifically have the property which changes with the positions with one parts can be manufactured.
[0008]
[Means for Solving the Problem] this invention -- the following -- (1) steel -- and -- Let the heat treatment method of (2) be a summary.
[0009] (1) At weight %, it is C. : 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel:1-24%, Cr:6-28%, Mo: 0.2-4.0 %, Nb : 0.03-2.0 %, less than [Cu:4.0%], The precipitation-hardening type high silicon steel to which less than [Ce:0.4%] and less than [La:0.4%] are contained W:4.0% or less less than [Co:3.0%], less than [aluminum:1.0%], less than [Ti:2.0%], V:4.0% or less, and B:3.0% or less, and the remainder is characterized by the bird clapper from Fe and an unescapable impurity.
[0010] (2) At weight %, it is C. : 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel:1-24%, Cr:6-28%, Mo: 0.2-4.0 %, less than [Nb:2.0%], less than [Cu:4.0%], W:4.0% or less, less than [Co:3.0%], less than [aluminum:1.0%], less than [Ti:2.0%], Less than [Ce:0.4%] and less than [La:0.4%] are contained V:4.0% or less and B:3.0% or less. Into the portion which needs that it is the heat treatment method of the parts made from a precipitation-hardening type high silicon steel that the remainder consists of Fe and an unescapable impurity, and the surface section of the part is a high degree of hardness The heat treatment method characterized by performing heat treatment from the following ** to ** one by one, and ** Accepting it with the following ** into the portion which does not need that the surface section is a high degree of hardness, or performing heat treatment of only ** and ** one by one.
[0011] ** Heat, and give an aging treatment by 600 - 700 ** after [900-1100 degrees C] quenching.
[0012] ** Quench after heating at 950-1150 degrees C.
[0013] ** Give an aging treatment by 400 - 600 **.
[0014] Above (2) The precipitation-hardening type high silicon steel which is the material steel of the parts for heat treatment is Nb. It is desirable that it is the steel to carry out 0.1-2.0 % content. Moreover, (2) It is desirable for high-frequency induction heating to perform heating of ** in the heat treatment method or/, and **.
[0015]
[Embodiments of the Invention] 1. It is this steel about the precipitation-hardening type high silicon steel (steel of the above (1)) of this invention. (it is described as "this invention steel" below) Precipitation-hardening nature of SHIRIKOROI (age-hardening property) It is the steel which made it possible to improve and to enlarge the case depth from a bill-of-materials side. First, the operation effect of each alloy content and the reason for limitation of a content are explained. In addition, % about a component content means weight %.
[0016] C:0.10%or less C is an element which raises the intensity of steel, and makes content of C of the specified quantity indispensable in the usual high intensity steel. However, in this invention steel containing a lot of Si, since intensity is secured by the unique metal texture brought about by Si, content of C is not indispensable. Rather, C is an element which has a bad influence also on oxidation resistance or corrosion resistance while reducing the toughness of this invention steel. Therefore, the content of C has the fewer possible good one. Although 0.10% is a permission upper limit, 0.05% or less is desirable and it is much more desirable to stop to 0.02 more% or less. With present refinement technology, the ingot of 0.01% or less of super-low carbon steel is also possible.
[0017] Si: 2.0 - 9.0 %Si is not only main elements which give intensity to this invention steel, but gives thermal resistance, oxidation resistance, corrosion resistance, and an elevated-temperature softening resistance. Moreover, it is also the element which lowers the melting point of steel, increases a fluidity and improves fluidity. The content When it is less than 2.0%, the improvement effect of the above-mentioned property is not enough. On the other hand, since Si is a powerful ferrite formation element, the content If it exceeds 9.0%, although it will stop that the ferrite phase under organization of steel becomes excessive, it is necessary to increase addition of nickel etc., and a material price becomes high.
[0018] Mn: 0.05 - 6.0 %Mn works as a deoxidizer of steel, and is also an austenite generation element. Although a mechanical property is not influenced greatly, since it is useful to precise-izing and stabilization of a metal texture, 0.05% or more needs to be contained of precipitation-hardening type stainless steel. However, if it exceeds 6.0%, corrosion resistance will deteriorate.

[0019] nickel: 1 - 24%nickel is corrosion resistance to steel. (especially acid resistance) While giving oxidation resistance and thermal resistance, it is an element indispensable although the metal texture of steel is kept substantial to a two phase in balance with Cr described below. More than 1 % is required to acquire these operation effects. However, if it exceeds 24%, the feature of a duplex stainless steel is not only lost, but an austenite phase will increase too much and the economical efficiency of steel will be lost.
[0020] In addition, although the organization of this invention steel mainly consists of a two phase of an austenite and martensite as mentioned above, a ferrite may exist out of it. A two phase means including such an organization substantially.
[0021] Cr : Cr is 6 to 28%, the fundamental property, i.e., corrosion resistance, of stainless steel. (especially acid resistance) It is a component for securing thermal resistance and oxidation resistance. 6 Under % of these properties is inadequate. On the other hand, if Cr exceeds 28%, the amount of nickel required in order to keep steel substantial to a two phase will increase, and economical efficiency will be spoiled.
[0022] Mo: 0.2 - 4.0 %Mo is the corrosion resistance of steel. (acid resistance) A high temperature strength is raised, and anti-creep nature is improved, and it contributes also to the improvement in toughness and abrasion resistance. 0.2 Under % of these effects is inadequate. Since it is a ferritizer, Mo must increase the addition of an austenite formation element (nickel, Cu, Mn), if the content increases. Moreover, Mo is also an expensive element. Synthetically in consideration of these things, the content of Mo determined it as 0.2-4.0 %.
[0023] Nb: 0.03-2.0 %Nb is an element effective in enlarging the case depth in the case of an aging treatment, without spoiling the toughness of this invention steel. Furthermore, Nb improves intergranular corrosion-proof nature and weldability, and raises intensity. As shown in drawing 3 -5 explained in detail later, even when the same heat treatment is performed, a deep case depth is obtained in the steel containing Nb. As for this effect, the content of Nb becomes remarkable at 0.03% or more. However, 2.0 If it exceeds, the hot-working nature of steel will be spoiled and the fall of toughness will also be caused. Therefore, the proper content of Nb is 0.03-2.0 %, and 0.1 - 1.5 % is still more desirable.
[0024] As mentioned above, although Nb is a component which enlarges a case depth, the material of the parts which apply the heat treatment method of this invention does not necessarily need to contain Nb. Even if it does not contain Nb so that it may mention later, the desired end is because it can attain. Therefore, the above (2) With the material steel of the parts which apply the heat treatment method, it is Nb. It may consider as 2.0% or less, and a minimum may be the level of an unescapable impurity.
[0025] Cu: Below 4.0 % Cu is the component added if needed. Cu is corrosion resistance. (especially acid resistance) It is the element contributed to precipitation hardening with an improvement. Moreover, it is useful to adjustment of the balance of a metal texture as an austenite formation element. When it expects these operations, it is good to make it contain more than 0.5 %. However, Cu exceeding 4.0 % is the upper limit of a content, even when adding, since the hot-working nature of steel is spoiled. You may be 4.0%. Desirable one It is 2.0% or less.
[0026] W: Below 4.0 % W raises the high temperature strength of steel like Mo, and since there is an operation which improves thermal resistance and anti-creep nature, add if needed. In the system of the SHIRIKOROI type III mentioned especially later, resistance to temper softening in an elevated temperature is enlarged, and a high temperature strength is maintained. It is desirable to make it contain 0.5% or more. However, W exceeding 4.0 % does not have an effect to the extent that elevation is balanced in the price of steel.
[0027] Each component further described below out of the above-mentioned component may contain in the range below each upper limit.
[0028] B: Since below 3.0 % B has the operation which raises the degree of hardness of steel remarkably, it is desirable to add in Type III of which the especially excellent abrasion resistance is required. However, B content Since the embrittlement of steel will become excessive and processability will be spoiled if it exceeds 3.0%, it is an upper limit. You may be 3.0%.
[0029] Co : Below 3.0 % Co is the component which raises a high temperature strength, without having a bad influence on the toughness of steel. However, since it is an expensive element, it is the upper limit of the content. You may be 3.0%.
[0030] aluminum: Below 1.0 % and Ti: Below 2.0 % and V: 4.0 % -- below, aluminum and Ti contribute these also to heat-resistant improvement while they improve the abrasion resistance of steel by precipitation-hardening operation However, since superfluous addition degrades toughness, even when adding it, a content is a power which below each upper limit stops.

[0031] Rare earth elements: 0.4% or less, rare earth elements, such as Ce and La, have the effect of deoxidation, desulfurization, and grain refining, and contribute to the improvement of the improvement in toughness, stress-corrosion-cracking-proof nature, and hot-working nature. These effects are each content of rare earth elements. It is mostly saturated even with 0.4%.
[0032] This invention steel consists of an impurity with the as unescapable remainder as iron (Fe) outside each above-mentioned component. In addition, as for the inside P and S of an impurity, it is desirable to stop to 0.04% or less, respectively.
[0033] Within the limits of the chemical composition described until now, this invention steel is classified into the steel of some systems with the property. The typical chemical composition is shown in Table 1. These are made to call it for convenience Type I of SHIRIKOROI, Type II, and Type III here. In addition, composition of the lower berth of each type of Table 1 is desirable composition.
[0034]
[Table 1]
表1

鋼種		化学組成 (wt%, 残部：Feおよび不純物)								
		C	Si	Mn	Ni	Cr	Mo	Nb	Cu	その他任意成分
シリコロイ	タイプI	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	1～12 3～ 5	6～25 8～16	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	W: 4.0 以下 Co: 3.0 以下 Al: 1.0 以下 Ti: 2.0 以下 V: 4.0 以下 B: 3.0 以下 希土類元素: 0.4 以下
	タイプII	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	3～16 5～10	6～25 8～16	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	
	タイプIII	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	4～24 6～16	10～28 16～25	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	

注） 各鋼の上段が標準の含有量の範囲、下段が望ましい範囲である。

[0035] Type I (SHIRIKOROIA) shown in Table 1 is comparatively cheap low nickel type steel. although mist and a mechanical property are inferior to Type II, if it compares with the nickel-Cr-Mo steel which carried out general hardening-tempering processing -- double precision -- it has near tough nature It is suitable to use it for a structural material as a plate, a bar, and mold material (angle etc.) taking advantage of the fundamental property of SHIRIKOROI.
[0036] Type II (SHIRIKOROI A2) is what raised nickel content of Type I, and is all-round type steel which has tough nature, thermal resistance, corrosion resistance, abrasion resistance, a sex with galling-proof, and a high degree of hardness. The main uses are the bearing roller for bridges, a roller for continuous casting machines, bearing, etc.
[0037] in addition, the desirable composition range which packed above-mentioned Type I and above-mentioned Type II -- below C:0.05 %, and Si:3.5-5.5 % and Mn: 0.05-3.0 %, nickel:3-10, Cr:8-16, Mo:0.2-2.5%, and Nb : 0.03-1.5, less than [Cu:2.0%], Remainder Fe, and an unescapable impurity -- it comes out
[0038] Type III (SHIRIKOROIC) raises especially a high temperature strength and abrasion resistance further among the properties with which Type II is equipped. This steel fits the parts of the engineering-works structural device which receives intense wear, the parts of various mixers, and the Snake screw. Furthermore, since it has the outstanding thermal resistance and outstanding abrasion resistance, it is suitable also for a severe use like the structure in a furnace of an incinerator. Of course, it can be used also for the same use as Types I and II.
[0039] 2. Above of this Invention (2) Material Steel of Parts Set as the Object of this Method about the Heat Treatment Method C: 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel: 1-24%, Cr:6-28%, Mo:0.2-4.0 %, Nb: Less than [2.0%], less than [Cu:4.0%], W:4.0% or less, less than [Co:3.0%], aluminum: It is the precipitation-hardening type high silicon steel which less than [Ce:0.4%] and less than [La:0.4%] are contained, and the remainder becomes from Fe and an unescapable impurity less than [1.0%], less than [Ti:2.0%], V:4.0% or less, and B:3.0% or less. It is not necessary to necessarily contain Nb which was an indispensable component in the aforementioned this invention steel. However, since Nb is an element which enlarges a case depth, it is very desirable. [of using the steel of which 0.03-2.0 % content is done as material steel of the parts which apply the heat treatment method of this invention]
[0040] Although the processes of heat treatment are the following three processes, it is the big feature of this

invention method to use the three processes properly according to the necessity of surface section hardening for every position of parts. Proper use of the process is shown in drawing 1 .
[0041] ** Process (temper process) : at this process It heats (primary heating), and after [900-1100 degrees C] quenching, it heats by 600 - 700 ** (secondary heating). Primary heating is the thickness of parts. (thick) Let 1 hours or more be a standard per inch. Cooling is oil quenching. (or water cooling) It considers as quenching to depend. Secondary heating also makes 1 hours or more a standard per inch in thickness of parts. Cooling after this secondary heating is good at air cooling.
[0042] Although primary heating of this process is one sort of solution treatment and secondary heating is equivalent to an aging treatment, the aging treatment of solution-izing of ** or ** described below is not full-scale. Heat treatments of this ** are one sort of temper processings, and by it, casting in part manufacture process and the influence of plastic working are removed, stress relief is carried out, and they make a metal texture detailed and homogeneous. Furthermore, it is preliminary processing for shortening the duration of heat treatment of the improvement in toughness by softening of the core part of parts, ** of a degree, and **, and ensuring the effect. Therefore, the surface hardness of the parts obtained is shore hardness. (it is hereafter written as HS) 40-45 (namely, HS 40-45) It is a grade.
[0043] ** Process : after heating this process at 950-1150 degrees C, it is solution treatment which quenches. Heating time is the depth (necessary case depth) which you want to harden. It responds and determines. Cooling is taken as quenching by water cooling. although the surface section of parts becomes a still more detailed organization by this processing -- the surface hardness of parts -- the processing back of the aforementioned ** -- almost -- not changing -- about -- It is HS 40-45. Therefore, in the state of this solution-izing, it machines and the configuration of parts is prepared. (finish is performed) Things are easy.
[0044] ** Process : this It is the aging-treatment process heated by 400 - 600 **. The processing time is per [of thickness] inch to parts. You may be 1 hours or more. In the portion to which heat treatment of the aforementioned ** and ** was performed, the heating temperature of the process of this ** is abbreviation. The highest hardness when it is 470 degrees C (70 or more HS(s)) It is obtained and an attainment degree of hardness falls before and behind it. 400 the low temperature of under ** -- or -- A desirable high degree of hardness is not obtained at an elevated temperature which exceeds 600 degrees C.
[0045] ** Since heat treatment is processing at low temperature as mentioned above, there is almost no possibility of causing deformation of parts. Therefore, after processing the last configuration after processing of **, ** can be heat-treated and a predetermined degree of hardness can be given.
[0046] Heat treatment of above ** (temper processing) It carries out to an entire component. On the other hand, heat treatment of ** and ** can be properly used in a following case 1 and a following case 2, as shown in drawing 1 .
[0047] [Case 1] ** is processed to an entire component, surface hardening, high-intensity-izing, and wear-resistant improvement perform processing of ** and ** to a required portion (A section), and surface hardening etc. is unnecessary and omits heat treatment of ** in the portion (B section) which thinks toughness as important rather.
[0048] [Case 2] ** is processed to an entire component, surface hardening, high-intensity-izing, and wear-resistant improvement give ** and ** to a required portion (A section), and surface hardening etc. is unnecessary and omits heat treatment of ** in the portion (B section) which thinks toughness as important rather.
[0049] the above -- only a portion surface hardening, high-intensity-izing, and wear-resistant improving has a high degree of hardness in any case, and the portion which is not so will be in the state where it is rich in toughness by the low degree of hardness This is concretely explained using the example of an examination.
[0050] Diameter shown in drawing 2 by being made from six kinds of steel shown in Table 2 47 mm, length 600 mm Three round bar forgings were prepared about each steel, respectively. And the following heat treatment was performed to each round bar. In addition, six kinds of steel of Table 2 adds Nb to the each with Type I of SHIRIKOROI shown in Table 1 to III.
[0051]
[Table 2]

表2

鋼種	化学組成 (wt%, 残部：Feおよび不純物)								
	C	Si	Mn	Ni	Cr	Mo	Nb	Cu	その他
タイプI	0.02	3.51	1.03	3.95	12.08	0.50	—	1.25	
タイプI－Nb	0.02	3.55	1.10	4.00	12.02	0.49	0.78	1.22	
タイプII	0.02	3.49	1.12	6.04	12.05	0.55	—	1.20	
タイプII－Nb	0.02	3.53	1.05	6.00	12.10	0.48	0.82	1.18	
タイプIII	0.02	3.50	1.03	9.95	20.05	2.02	—	1.24	W:2.50,Co:1.05,V:1.30,Ti:0.20,Al:0.10
タイプIII－Nb	0.02	3.55	1.10	10.02	19.96	2.10	0.75	1.20	W:2.52,Co:1.00,V:1.25,Ti:0.23,Al:0.13

[0052] [heat treatment
** Round bar whole It is 120 at 950 degrees C. After part-heating, water cooling is carried out and it ranks second. At 650 degrees C Temper processing which heats for 120 minutes and carries out air cooling (processing of the aforementioned **) .
[0053] ** Solution treatment which heats only the A section of the round bar at 1050 degrees C, and carries out water cooling immediately while moving the coil for high-frequency induction heating by 1.5 mm/sec (processing of the aforementioned **) . In addition, the conditions of this high-frequency induction heating are the same as the example mentioned later.
[0054] ** Round bar whole It is 120 at 480 degrees C. Part-heated aging treatment (processing of the aforementioned **) .
[0055] The next examination was performed about the round bar after the above-mentioned heat treatment.
[0056] [An impact test and tension test] The A section of the round bar (portion to which all heat treatments of the above-mentioned ** - ** were performed) And the B section (portion to which heat treatment of the above-mentioned ** is not performed) The shaft center section to piece of a Charpy impact test (JIS No. 4) Test piece for tensile test (JIS No. 8) It extracted and the 25-degree C impact test and the tension test in a room temperature were performed.
[0057] [Measurement of a hardness test-case depth] The disk-like test piece was extracted from the A section and the B section of the round bar right-angled to the medial axis, and the hardening distribution from a front face was measured. These measurement results are shown in Table 3 and drawing 3 -5. In addition, HS 65 shown all over drawing here in a thick horizontal line The above portion was defined as the hardening layer.
[0058]
[Table 3]
表3

鋼種	タイプI		タイプI－Nb		タイプII		タイプII－Nb		タイプIII		タイプIII－Nb	
機械的性質	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部
引張強度 (kgf/mm²)	141	102	139	103	152	113	154	111	172	119	171	122
0.2%耐力 (kgf/mm²)	106	87	102	86	113	102	116	101	135	107	131	109
伸び (%)	19	25	20	24	15	23	14	24	8	18	7	17
衝撃値(kgf-m/cm²)	11	17	12	16	13	20	14	21	16	22	16	21
最大硬度 (HS)	67	38	68	40	69	42	70	44	72	45	73	47
硬化深度 (mm)	1.5	0	3.3	0	1.7	0	3.5	0	1.8	0	3.5	0

[0059] From drawing 3 to drawing 5 If the degree-of-hardness distribution of the A section which performed all heat treatments from ** to ** shown in the (a) view is seen, as for the case depth, the direction of the steel (type I-Nb, type II-Nb, type III-Nb) which added Nb to each rather than type I-III which does not contain Nb is deep. On the other hand, they are drawing 3 - drawing 5 . As shown in the (b) view, in the B section which has not performed solution treatment of **, a hardening layer is not seen and does not almost have change of a degree

of hardness from the surface section to a core part.
[0060] The impact resistance value of the core shown in Table 3, and measured value of a tension test (tensile strength, proof stress, elongation) If it sees, also in which type of steel, the elongation and the impact resistance value of the B section are larger than the A section.
[0061] The next conclusion is obtained from the above-mentioned result.
[0062] 1) Even if it is parts made from SHIRIKOROI of the same composition, a different mechanical property can be given by changing heat treatment conditions for every position of the. Namely, on the other hand, the portion (the aforementioned B section) which excluded heat treatment of ** is rich in toughness with hardness with the uniform whole by the ability forming a hardening layer in a surface with the portion (the aforementioned A section) which performed all heat treatments from ** to **.
[0063] 2) By any type of SHIRIKOROI, a case depth can be made deep by adding Nb. Therefore, what is necessary is just to use the steel which contains Nb as material steel for the parts for which a thick hardening layer is needed. Since a case depth is dependent also on the aging-treatment time of **, its use of Nb content steel is advantageous to shorten the time and raise productivity.
[0064] Although these are the examples of an examination of the aforementioned case 1, the almost same result is obtained also in the example of an examination of a case 2. However, by the examination of a case 2, it carries out by the usual method of heating the whole and quenching, and the solution treatment of ** is a radio frequency heating method only about a required mosquito place (A section) in heat treatment of **. It carried out by the method of heating at 480 degrees C.
[0065] According to the heat treatment method of this invention the above-mentioned passage, even if it is one part, it is possible to give a locally different property by whether heat treatment of whether ** is heat-treated and ** is performed.
[0066] As the hard facing method of steel parts, a carburization hardening process, nitriding, etc. are common knowledge. Although these methods are suitable for the hard facing of an entire component, using for the local hard facing of parts is difficult methods. Moreover, with a carburization hardening process, since heating at high temperature and quenching are required, deformation of parts is caused, and there is also a difficulty that processing takes a long time, by nitriding. On the other hand, although hardening performs solution treatment of ** or ** only to a required portion by this invention method, the heating can be easily carried out by the radio frequency heating method etc. And since the parts after this solution treatment are not yet hardened, they are easy to finish-machine with machining. Subsequent aging treatment Since it is carried out at the low temperature 400-600 **, deformation of parts hardly becomes a problem.
[0067]
[Example] Six kinds of steel shown in the above-mentioned table 1 is used, and it is absolute-size size. (diameter of about 80mm) The valve rod of the relief valve of a pump was produced and it processed by the heat treatment method of this invention. It is drawing 6 about the appearance and the boundary dimension of a valve rod. It is shown in (a). This valve rod is for the pressure inside a pump not exceeding constant value. It is the structure which will fall if a valve rod will go up, an internal pressure will be missed if the pressure inside a pump exceeds a critical value, and a pressure declines, and is settled in a valve seat. Therefore, while the tough nature which bears the shock when colliding with a valve seat is required for a valve rod, the abrasion resistance (high degree of hardness) excellent in a point and the sliding section is required.
[0068] Heat treatment conditions and the test condition are as follows.
[0069] [heat treatment
** Valve rod whole It is 180 at 950 degrees C. Water cooling is carried out after part-heating. subsequently -- 650 degrees C the A section (sliding section) and the C section (point) of a temper processing ** valve rod which heat for 180 minutes and carry out air cooling -- high-frequency induction heating -- coil feed rate it is the solution treatment which heats and carries out water cooling to 1050 degrees C by 1.5 mm/sec -- this high-frequency induction heating -- frequency: -- it carried out by 30kHz and electric capacity:150 KW, and the water jet from the jacket prepared immediately after the coil performed cooling
[0070] ** Valve rod whole At 480 degrees C Aging treatment heated for 180 minutes.
[0071] [an impact test and a tension test] -- the A section of a valve rod (portion to which all heat treatments of the above-mentioned ** - ** were performed) And the B section (portion to which heat treatment of the above-mentioned ** is not performed) A center to piece of a Charpy impact test (JIS No. 4) Test piece for tensile test (JIS No. 8) it extracts -- the impact test in 25 ** and the tension test in a room temperature were performed

[0072] [Measurement of a hardness test-case depth] The disk-like test piece was extracted from the A section and the B section of a valve rod right-angled to the medial axis, and the degree-of-hardness distribution from a front face was measured. The C section (point) If attached, only the degree-of-hardness distribution of the surface section was measured. These measurement results are indicated to be Table 4 to drawing 7 -9.
[0073]
[Table 4]
表4

鋼種	タイプI		タイプI-Nb		タイプII		タイプII-Nb		タイプIII		タイプIII-Nb	
機械的性質	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部
引張強度 (kgf/mm²)	143	100	137	105	150	110	149	109	170	117	171	116
0.2%耐力 (kgf/mm²)	108	85	99	93	111	101	116	102	132	105	126	103
伸び (%)	20	26	14	21	16	24	13	26	9	18	8	16
衝撃値(kgf-m/cm²)	12	18	18	17	14	22	13	20	15	23	14	24
最大硬度 (HS)	67	38	68	40	69	41	71	43	73	44	74	46
硬化深度 (mm)	2	0	4	0	2	0	4.7	0	2.2	0	4.5	0
C部最大硬度 (HS)	68		68		71		72		74		75	
C部硬化深度 (mm)	1.8		3.6		1.9		4.2		2		4.4	

[0074] A hardening layer is formed, and although the hardening layer thickness (case depth) contains Nb, in every steel type from Type I to III, the direction is large [layer thickness] in the A section which performed all heat treatments from ** to **, so that clearly from drawing 7 - drawing 9 . That is, even if it is heat treatment on the same conditions, in the valve rod of this invention steel containing Nb, a hard facing layer becomes deep. When in other words obtaining the hardening layer of the same depth, the direction of steel RO can be managed with a short-time aging treatment.
[0075] the B section (namely, portion which has not performed solution treatment of **) **** -- a hardening layer does not exist It is clear from this that it is possible to establish the field which is locally rich in abrasion resistance by the high degree of hardness in the position of parts. And as shown in Table 4, since the core part of parts is tough in every portion, the shock resistance of parts is also fully secured.
[0076] The maximum degree of hardness and case depth of the C section which were appended to Table 4 are almost the same as the A section. That is, a valve rod point has a high degree of hardness, and is excellent in abrasion resistance. Although the mechanical property of the core part of the C section is not measured, it is clear to have the same property as the A section, and a core part can be presumed to be what is rich in tough nature.
[0077] In the above-mentioned example, after heat treatment of **, screw cutter processing of the B section of a valve rod was performed, before heat-treating ** in the A section and the C section. However, since ** is not heat-treated as mentioned above in the B section, the surface section is hardly hardened to the last, either. Therefore, after all heat treatments of the whole valve rod are completed, you may perform screw cutter processing. Few more distorted parts can be obtained by doing so.
[0078] The former and this kind of valve rod is JIS. SUS 630 Steel (precipitation hardening stainless steel) It is produced. this steel -- an aging treatment of after -- a degree of hardness -- at most -- It goes up only to about 50 HS. therefore, the building-up according to a Stellite in a valve rod nose of cam -- giving -- further -- Gas-nitriding processing which is called 60 hours at 500 degrees C was performed, and it was considering as the product. And the SUS 630 A steel valve rod is inferior to the valve rod produced by this invention method in an impact resistance value and elongation. Furthermore, the valve rod produced by this invention method has little distortion, and won also in the corrosion resistance and corrosion resistance in sea water to a sulfuric acid, a hydrochloric acid, etc.
[0079]
[Effect of the Invention] According to this invention method characterized by selecting material steel and heat treatment conditions proper, various properties can be given to parts. Processing in which only the specific

position of one part is stiffened especially can also be carried out easily.
[0080] Since the precipitation-hardening die steel containing Nb of this invention can enlarge a case depth, if this steel is used, manufacture of the large parts of a case depth or shortening of a manufacturing process will be attained.
[0081] this invention is applicable to manufacture of all the parts by which to have various properties, such as corrosion resistance, thermal resistance, and abrasion resistance, with tough nature, such as various rolls of the screw shaft of a chemical processing plant, a driveshaft, and an iron-manufacture plant, a roller, and a roller of bearing for bridges, is needed out of the valve rod shown in the example.

[Translation done.]

* NOTICES *

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TECHNICAL FIELD

[The technical field to which invention belongs] This invention is machine parts, such as a shaft of various devices, a roll, a roller, and bearing, and relates to the heat treatment method for manufacturing the parts a high silicon steel [type / precipitation-hardening / suitable as a material of the parts for which to have a tough nature and high degree of hardness, abrasion resistance, anticorrosion thermal resistance, etc. is needed], and above-mentioned.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Roll of various kinds of devices used for a chemical processing plant, an iron-manufacture plant, a building construction, etc. (roller) Shaft (shaft) Many [the parts of which tough nature, such as bearing and abrasion resistance are required simultaneously] In order to meet these demands, only a front face becomes a high degree of hardness, and the material to which a core part is rich in toughness is needed by suitable processing. As the art, a cementation process, nitriding, an induction hardening method, etc. are common knowledge, and various steel materials suitable for these processings are also developed.

[0003] In addition to tough nature and abrasion resistance, with the parts used under corrosive environment or an elevated temperature, corrosion resistance and thermal resistance are needed in many cases simultaneously. For example, tough nature and not only abrasion resistance but the outstanding corrosion resistance which bears a rainstorm or salt damage is required of the roller of the roller bearing which absorbs expansion and contraction of a bridge. Moreover, segment of the mold lower part of metaled continuous casting equipment (cast piece guide apparatus) In addition to high intensity and abrasion resistance, a high temperature strength and sufficient thermal resistance are also needed for the roll of the roller and rolling mill to constitute, and advanced corrosion resistance, such as acid resistance, is required of the parts for chemical processing plants.

[0004] As anticorrosion and a heat-resistant material, the austenitic stainless steel which makes Cr and nickel a major component is common. However, this stainless steel has intensity and a low degree of hardness, and they are unsuitable into a wear-resistant material of high intensity. Precipitation-hardening type steel is JIS as stainless steel which becomes high intensity and a high degree of hardness comparatively. Although standardized as SUS 630 and 631, this steel cannot respond to a severe service condition in recent years in cases, either. On the other hand, as hardening hardening type stainless steel, although SUS 440 and the 420J2 grade are known, it is the product. (for example, roller) When it hardens, the whole hardens to the core part of a product and there is a problem of losing toughness and becoming easy to break.

[0005] It is high intensity and quantity toughness, and excels also in corrosion resistance and thermal resistance, and there is "quantity silicon stainless steel" as steel equipped also with a high degree of hardness. This steel is patent 619,383rd. Number (JP,46-9536,B) It was patented by carrying out and the improvement steel is JP,57-17070,B further. (the 1,167,791st number of a patent) It is indicated. Such high silicon stainless steel is SHIRIKOROI. (registered trademark) It is called, and it is put in practical use by these people and has come to be used widely in recent years.

[0006] Above-mentioned SHIRIKOROI is steel of age-hardening nature which mainly has the two phase organization of an austenite and martensite. These people did patent application of the invention about the heat treatment previously. (refer to JP,7-97623,A) . The invention is invention which is a thing aiming at obtaining a deep case depth, and is comparatively characterized by three steps of heat treatment processes of a temper, solution-izing, and aging with short-time heat treatment.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention method characterized by selecting material steel and heat treatment conditions proper, various properties can be given to parts. Processing in which only the specific position of one part is stiffened especially can also be carried out easily.

[0080] Since the precipitation-hardening die steel containing Nb of this invention can enlarge a case depth, if this steel is used, manufacture of the large parts of a case depth or shortening of a manufacturing process will be attained.

[0081] this invention is applicable to manufacture of all the parts by which to have various properties, such as corrosion resistance, thermal resistance, and abrasion resistance, with tough nature, such as various rolls of the screw shaft of a chemical processing plant, a driveshaft, and an iron-manufacture plant, a roller, and a roller of bearing for bridges, is needed out of the valve rod shown in the example.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] One of the purposes of this invention is to offer the new alloy which added improvement further, after employing the property of aforementioned SHIRIKOROI efficiently. Furthermore, another purpose is to offer the heat treatment method which gives the most desirable function to various parts made from SHIRIKOROI and its modified alloy, and the new heat treatment method that the parts which specifically have the property which changes with the positions with one parts can be manufactured.

[Translation done.]

MEANS

[Means for Solving the Problem] this invention -- the following -- (1) steel -- and -- Let the heat treatment method of (2) be a summary.
[0009] (1) At weight %, it is C. : 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel:1-24%, Cr:6-28%, Mo: 0.2-4.0 %, Nb : 0.03-2.0 %, less than [Cu:4.0%], The precipitation-hardening type high silicon steel to which less than [Ce:0.4%] and less than [La:0.4%] are contained W:4.0% or less less than [Co:3.0%], less than [aluminum:1.0%], less than [Ti:2.0%], V:4.0% or less, and B:3.0% or less, and the remainder is characterized by the bird clapper from Fe and an unescapable impurity.
[0010] (2) At weight %, it is C. : 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel:1-24%, Cr:6-28%, Mo: 0.2-4.0 %, less than [Nb:2.0%], less than [Cu:4.0%], W:4.0% or less, less than [Co:3.0%], less than [aluminum:1.0%], less than [Ti:2.0%], Less than [Ce:0.4%] and less than [La:0.4%] are contained V:4.0% or less and B:3.0% or less. Into the portion which needs that it is the heat treatment method of the parts made from a precipitation-hardening type high silicon steel that the remainder consists of Fe and an unescapable impurity, and the surface section of the part is a high degree of hardness The heat treatment method characterized by performing heat treatment from the following ** to ** one by one, and ** Accepting it with the following ** into the portion which does not need that the surface section is a high degree of hardness, or performing heat treatment of only ** and ** one by one.
[0011] ** Heat, and give an aging treatment by 600 - 700 ** after [900-1100 degrees C] quenching.
[0012] ** Quench after heating at 950-1150 degrees C.
[0013] ** Give an aging treatment by 400 - 600 **.
[0014] Above (2) The precipitation-hardening type high silicon steel which is the material steel of the parts for heat treatment is Nb. It is desirable that it is the steel to carry out 0.1-2.0 % content. Moreover, (2) It is desirable for high-frequency induction heating to perform heating of ** in the heat treatment method or/, and **.
[0015]
[Embodiments of the Invention] 1. It is this steel about the precipitation-hardening type high silicon steel (steel of the above (1)) of this invention. (it is described as "this invention steel" below) Precipitation-hardening nature of SHIRIKOROI (age-hardening property) It is the steel which made it possible to improve and to enlarge the case depth from a bill-of-materials side. First, the operation effect of each alloy content and the reason for limitation of a content are explained. In addition, % about a component content means weight %.
[0016] C:0.10%or less C is an element which raises the intensity of steel, and makes content of C of the specified quantity indispensable in the usual high intensity steel. However, in this invention steel containing a lot of Si, since intensity is secured by the unique metal texture brought about by Si, content of C is not indispensable. Rather, C is an element which has a bad influence also on oxidation resistance or corrosion resistance while reducing the toughness of this invention steel. Therefore, the content of C has the fewer possible good one. Although 0.10% is a permission upper limit, 0.05% or less is desirable and it is much more desirable to stop to 0.02 more% or less. With present refinement technology, the ingot of 0.01% or less of super-low carbon steel is also possible.
[0017] Si: 2.0 - 9.0 %Si is not only main elements which give intensity to this invention steel, but gives thermal resistance, oxidation resistance, corrosion resistance, and an elevated-temperature softening resistance. Moreover, it is also the element which lowers the melting point of steel, increases a fluidity and improves fluidity. The content When it is less than 2.0%, the improvement effect of the above-mentioned property is not enough. On the other hand, since Si is a powerful ferrite formation element, the content If it exceeds 9.0%, although it will stop that the ferrite phase under organization of steel becomes excessive, it is necessary to

increase addition of nickel etc., and a material price becomes high.
[0018] Mn: 0.05 - 6.0 %Mn works as a deoxidizer of steel, and is also an austenite generation element. Although a mechanical property is not influenced greatly, since it is useful to precise-izing and stabilization of a metal texture, 0.05% or more needs to be contained of precipitation-hardening type stainless steel. However, if it exceeds 6.0%, corrosion resistance will deteriorate.
[0019] nickel: 1 - 24%nickel is corrosion resistance to steel. (especially acid resistance) While giving oxidation resistance and thermal resistance, it is an element indispensable although the metal texture of steel is kept substantial to a two phase in balance with Cr described below. More than 1 % is required to acquire these operation effects. However, if it exceeds 24%, the feature of a duplex stainless steel is not only lost, but an austenite phase will increase too much and the economical efficiency of steel will be lost.
[0020] In addition, although the organization of this invention steel mainly consists of a two phase of an austenite and martensite as mentioned above, a ferrite may exist out of it. A two phase means including such an organization substantially.
[0021] Cr : Cr is 6 to 28%, the fundamental property, i.e., corrosion resistance, of stainless steel. (especially acid resistance) It is a component for securing thermal resistance and oxidation resistance. 6 Under % of these properties is inadequate. On the other hand, if Cr exceeds 28%, the amount of nickel required in order to keep steel substantial to a two phase will increase, and economical efficiency will be spoiled.
[0022] Mo: 0.2 - 4.0 %Mo is the corrosion resistance of steel. (acid resistance) A high temperature strength is raised, and anti-creep nature is improved, and it contributes also to the improvement in toughness and abrasion resistance. 0.2 Under % of these effects is inadequate. Since it is a ferritizer, Mo must increase the addition of an austenite formation element (nickel, Cu, Mn), if the content increases. Moreover, Mo is also an expensive element. Synthetically in consideration of these things, the content of Mo determined it as 0.2-4.0 %.
[0023] Nb: 0.03-2.0 %Nb is an element effective in enlarging the case depth in the case of an aging treatment, without spoiling the toughness of this invention steel. Furthermore, Nb improves intergranular corrosion-proof nature and weldability, and raises intensity. As shown in drawing 3 -5 explained in detail later, even when the same heat treatment is performed, a deep case depth is obtained in the steel containing Nb. As for this effect, the content of Nb becomes remarkable at 0.03% or more. However, 2.0 If it exceeds, the hot-working nature of steel will be spoiled and the fall of toughness will also be caused. Therefore, the proper content of Nb is 0.03-2.0 %, and 0.1 - 1.5 % is still more desirable.
[0024] As mentioned above, although Nb is a component which enlarges a case depth, the material of the parts which apply the heat treatment method of this invention does not necessarily need to contain Nb. Even if it does not contain Nb so that it may mention later, the desired end is because it can attain. Therefore, the above (2) With the material steel of the parts which apply the heat treatment method, it is Nb. It may consider as 2.0% or less, and a minimum may be the level of an unescapable impurity.
[0025] Cu: Below 4.0 % Cu is the component added if needed. Cu is corrosion resistance. (especially acid resistance) It is the element contributed to precipitation hardening with an improvement. Moreover, it is useful to adjustment of the balance of a metal texture as an austenite formation element. When it expects these operations, it is good to make it contain more than 0.5 %. However, Cu exceeding 4.0 % is the upper limit of a content, even when adding, since the hot-working nature of steel is spoiled. You may be 4.0%. Desirable one It is 2.0% or less.
[0026] W: Below 4.0 % W raises the high temperature strength of steel like Mo, and since there is an operation which improves thermal resistance and anti-creep nature, add if needed. In the system of the SHIRIKOROI type III mentioned especially later, resistance to temper softening in an elevated temperature is enlarged, and a high temperature strength is maintained. It is desirable to make it contain 0.5% or more. However, W exceeding 4.0 % does not have an effect to the extent that elevation is balanced in the price of steel.
[0027] Each component further described below out of the above-mentioned component may contain in the range below each upper limit.
[0028] B: Since below 3.0 % B has the operation which raises the degree of hardness of steel remarkably, it is desirable to add in Type III of which the especially excellent abrasion resistance is required. However, B content Since the embrittlement of steel will become excessive and processability will be spoiled if it exceeds 3.0%, it is an upper limit. You may be 3.0%.
[0029] Co : Below 3.0 % Co is the component which raises a high temperature strength, without having a bad influence on the toughness of steel. However, since it is an expensive element, it is the upper limit of the

content. You may be 3.0%.
[0030] aluminum: Below 1.0 % and Ti: Below 2.0 % and V: 4.0 % -- below, aluminum and Ti contribute these also to heat-resistant improvement while they improve the abrasion resistance of steel by precipitation-hardening operation However, since superfluous addition degrades toughness, even when adding it, a content is a power which below each upper limit stops.
[0031] Rare earth elements: 0.4% or less, rare earth elements, such as Ce and La, have the effect of deoxidation, desulfurization, and grain refining, and contribute to the improvement of the improvement in toughness, stress-corrosion-cracking-proof nature, and hot-working nature. These effects are each content of rare earth elements. It is mostly saturated even with 0.4%.
[0032] This invention steel consists of an impurity with the as unescapable remainder as iron (Fe) outside each above-mentioned component. In addition, as for the inside P and S of an impurity, it is desirable to stop to 0.04% or less, respectively.
[0033] Within the limits of the chemical composition described until now, this invention steel is classified into the steel of some systems with the property. The typical chemical composition is shown in Table 1. These are made to call it for convenience Type I of SHIRIKOROI, Type II, and Type III here. In addition, composition of the lower berth of each type of Table 1 is desirable composition.
[0034]
[Table 1]
表1

鋼種		化学組成 (wt%, 残部：Feおよび不純物)								
		C	Si	Mn	Ni	Cr	Mo	Nb	Cu	その他任意成分
シリコロイ	タイプI	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	1～12 3～ 5	6～25 8～16	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	W: 4.0 以下 Co: 3.0 以下 Al: 1.0 以下 Ti: 2.0 以下 V: 4.0 以下 B: 3.0 以下 希土類元素: 0.4 以下
	タイプII	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	3～16 5～10	6～25 8～16	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	
	タイプIII	0.10 以下 0.05 以下	2.0～9.0 3.5～5.5	0.05～6.0 0.05～3.0	4～24 6～16	10～28 16～25	0.2～4.0 0.2～2.5	2.0以下 0.03～2.0	4.0以下 2.0以下	

注） 各鋼の上段が標準の含有量の範囲、下段が望ましい範囲である。

[0035] Type I (SHIRIKOROIA) shown in Table 1 is comparatively cheap low nickel type steel. although mist and a mechanical property are inferior to Type II, if it compares with the nickel-Cr-Mo steel which carried out general hardening-tempering processing -- double precision -- it has near tough nature It is suitable to use it for a structural material as a plate, a bar, and mold material (angle etc.) taking advantage of the fundamental property of SHIRIKOROI.
[0036] Type II (SHIRIKOROI A2) is what raised nickel content of Type I, and is all-round type steel which has tough nature, thermal resistance, corrosion resistance, abrasion resistance, a sex with galling-proof, and a high degree of hardness. The main uses are the bearing roller for bridges, a roller for continuous casting machines, bearing, etc.
[0037] in addition, the desirable composition range which packed above-mentioned Type I and above-mentioned Type II -- below C:0.05 %, and Si:3.5-5.5 % and Mn: 0.05-3.0 %, nickel:3-10, Cr:8-16, Mo:0.2-2.5%, and Nb : 0.03-1.5, less than [Cu:2.0%], Remainder Fe, and an unescapable impurity -- it comes out
[0038] Type III (SHIRIKOROIC) raises especially a high temperature strength and abrasion resistance further among the properties with which Type II is equipped. This steel fits the parts of the engineering-works structural device which receives intense wear, the parts of various mixers, and the Snake screw. Furthermore, since it has the outstanding thermal resistance and outstanding abrasion resistance, it is suitable also for a severe use like the structure in a furnace of an incinerator. Of course, it can be used also for the same use as Types I and II.
[0039] 2. Above of this Invention (2) Material Steel of Parts Set as the Object of this Method about the Heat Treatment Method C: 0.10% or less, Si:2.0-9.0 %, Mn: 0.05-6.0 %, nickel: 1-24%, Cr:6-28%, Mo:0.2-4.0 %, Nb: Less than [2.0%], less than [Cu:4.0%], W:4.0% or less, less than [Co:3.0%], aluminum: It is the precipitation-hardening type high silicon steel which less than [Ce:0.4%] and less than [La:0.4%] are contained, and the remainder becomes from Fe and an unescapable impurity less than [1.0%], less than

[Ti:2.0%], V:4.0% or less, and B:3.0% or less. It is not necessary to necessarily contain Nb which was an indispensable component in the aforementioned this invention steel. However, since Nb is an element which enlarges a case depth, it is very desirable. [of using the steel of which 0.03-2.0 % content is done as material steel of the parts which apply the heat treatment method of this invention]

[0040] Although the processes of heat treatment are the following three processes, it is the big feature of this invention method to use the three processes properly according to the necessity of surface section hardening for every position of parts. Proper use of the process is shown in drawing 1 .

[0041] ** Process (temper process) : at this process It heats (primary heating), and after [900-1100 degrees C] quenching, it heats by 600 - 700 ** (secondary heating). Primary heating is the thickness of parts. (thick) Let 1 hours or more be a standard per inch. Cooling is oil quenching. (or water cooling) It considers as quenching to depend. Secondary heating also makes 1 hours or more a standard per inch in thickness of parts. Cooling after this secondary heating is good at air cooling.

[0042] Although primary heating of this process is one sort of solution treatment and secondary heating is equivalent to an aging treatment, the aging treatment of solution-izing of ** or ** described below is not full-scale. Heat treatments of this ** are one sort of temper processings, and by it, casting in part manufacture process and the influence of plastic working are removed, stress relief is carried out, and they make a metal texture detailed and homogeneous. Furthermore, it is preliminary processing for shortening the duration of heat treatment of the improvement in toughness by softening of the core part of parts, ** of a degree, and **, and ensuring the effect. Therefore, the surface hardness of the parts obtained is shore hardness. (it is hereafter written as HS) 40-45 (namely, HS 40-45) It is a grade.

[0043] ** Process : after heating this process at 950-1150 degrees C, it is solution treatment which quenches. Heating time is the depth (necessary case depth) which you want to harden. It responds and determines. Cooling is taken as quenching by water cooling. although the surface section of parts becomes a still more detailed organization by this processing -- the surface hardness of parts -- the processing back of the aforementioned ** -- almost -- not changing -- about -- It is HS 40-45. Therefore, in the state of this solution-izing, it machines and the configuration of parts is prepared. (finish is performed) Things are easy.

[0044] ** Process : this It is the aging-treatment process heated by 400 - 600 **. The processing time is per [of thickness] inch to parts. You may be 1 hours or more. In the portion to which heat treatment of the aforementioned ** and ** was performed, the heating temperature of the process of this ** is abbreviation. The highest hardness when it is 470 degrees C (70 or more HS(s)) It is obtained and an attainment degree of hardness falls before and behind it. 400 the low temperature of under ** -- or -- A desirable high degree of hardness is not obtained at an elevated temperature which exceeds 600 degrees C.

[0045] ** Since heat treatment is processing at low temperature as mentioned above, there is almost no possibility of causing deformation of parts. Therefore, after processing the last configuration after processing of **, ** can be heat-treated and a predetermined degree of hardness can be given.

[0046] Heat treatment of above ** (temper processing) It carries out to an entire component. On the other hand, heat treatment of ** and ** can be properly used in a following case 1 and a following case 2, as shown in drawing 1 .

[0047] [Case 1] ** is processed to an entire component, surface hardening, high-intensity-izing, and wear-resistant improvement perform processing of ** and ** to a required portion (A section), and surface hardening etc. is unnecessary and omits heat treatment of ** in the portion (B section) which thinks toughness as important rather.

[0048] [Case 2] ** is processed to an entire component, surface hardening, high-intensity-izing, and wear-resistant improvement give ** and ** to a required portion (A section), and surface hardening etc. is unnecessary and omits heat treatment of ** in the portion (B section) which thinks toughness as important rather.

[0049] the above -- only a portion surface hardening, high-intensity-izing, and wear-resistant improving has a high degree of hardness in any case, and the portion which is not so will be in the state where it is rich in toughness by the low degree of hardness This is concretely explained using the example of an examination.

[0050] Diameter shown in drawing 2 by being made from six kinds of steel shown in Table 2 47 mm, length 600 mm Three round bar forgings were prepared about each steel, respectively. And the following heat treatment was performed to each round bar. In addition, six kinds of steel of Table 2 adds Nb to the each with Type I of SHIRIKOROI shown in Table 1 to III.

[0051]
[Table 2]
表2

鋼種	化学組成 (wt%, 残部：Feおよび不純物)								
	C	Si	Mn	Ni	Cr	Mo	Nb	Cu	その他
タイプI	0.02	3.51	1.03	3.95	12.08	0.50	—	1.25	
タイプI－Nb	0.02	3.55	1.10	4.00	12.02	0.49	0.78	1.22	
タイプII	0.02	3.49	1.12	6.04	12.05	0.55	—	1.20	
タイプII－Nb	0.02	3.53	1.05	6.00	12.10	0.48	0.82	1.18	
タイプIII	0.02	3.50	1.03	9.95	20.05	2.02	—	1.24	W:2.50, Co:1.05, V:1.30, Ti:0.20, Al:0.10
タイプIII－Nb	0.02	3.55	1.10	10.02	19.96	2.10	0.75	1.20	W:2.52, Co:1.00, V:1.25, Ti:0.23, Al:0.13

[0052] [heat treatment
** Round bar whole It is 120 at 950 degrees C. After part-heating, water cooling is carried out and it ranks second. At 650 degrees C Temper processing which heats for 120 minutes and carries out air cooling (processing of the aforementioned **) .
[0053] ** Solution treatment which heats only the A section of the round bar at 1050 degrees C, and carries out water cooling immediately while moving the coil for high-frequency induction heating by 1.5 mm/sec (processing of the aforementioned **) . In addition, the conditions of this high-frequency induction heating are the same as the example mentioned later.
[0054] ** Round bar whole It is 120 at 480 degrees C. Part-heated aging treatment (processing of the aforementioned **) .
[0055] The next examination was performed about the round bar after the above-mentioned heat treatment.
[0056] [An impact test and tension test] The A section of the round bar (portion to which all heat treatments of the above-mentioned ** - ** were performed) And the B section (portion to which heat treatment of the above-mentioned ** is not performed) The shaft center section to piece of a Charpy impact test (JIS No. 4) Test piece for tensile test (JIS No. 8) It extracted and the 25-degree C impact test and the tension test in a room temperature were performed.
[0057] [Measurement of a hardness test-case depth] The disk-like test piece was extracted from the A section and the B section of the round bar right-angled to the medial axis, and the hardening distribution from a front face was measured. These measurement results are shown in Table 3 and drawing 3 -5. In addition, HS 65 shown all over drawing here in a thick horizontal line The above portion was defined as the hardening layer.
[0058]
[Table 3]
表3

鋼種	タイプI		タイプI－Nb		タイプII		タイプII－Nb		タイプIII		タイプIII－Nb	
機械的性質	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部
引張強度 (kgf/mm²)	141	102	139	103	152	113	154	111	172	119	171	122
0.2%耐力 (kgf/mm²)	106	87	102	86	113	102	116	101	135	107	131	109
伸び (%)	19	25	20	24	15	23	14	24	8	18	7	17
衝撃値(kgf-m/cm²)	11	17	12	16	13	20	14	21	16	22	16	21
最大硬度 (HS)	67	38	68	40	69	42	70	44	72	45	73	47
硬化深度 (mm)	1.5	0	3.3	0	1.7	0	3.5	0	1.8	0	3.5	0

[0059] From drawing 3 to drawing 5 If the degree-of-hardness distribution of the A section which performed all heat treatments from ** to ** shown in the (a) view is seen, as for the case depth, the direction of the steel (type I-Nb, type II-Nb, type III-Nb) which added Nb to each rather than type I-III which does not contain Nb is deep.

On the other hand, they are drawing 3 - drawing 5 . As shown in the (b) view, in the B section which has not performed solution treatment of **, a hardening layer is not seen and does not almost have change of a degree of hardness from the surface section to a core part.
[0060] The impact resistance value of the core shown in Table 3, and measured value of a tension test (tensile strength, proof stress, elongation) If it sees, also in which type of steel, the elongation and the impact resistance value of the B section are larger than the A section.
[0061] The next conclusion is obtained from the above-mentioned result.
[0062] 1) Even if it is parts made from SHIRIKOROI of the same composition, a different mechanical property can be given by changing heat treatment conditions for every position of the. Namely, on the other hand, the portion (the aforementioned B section) which excluded heat treatment of ** is rich in toughness with hardness with the uniform whole by the ability forming a hardening layer in a surface with the portion (the aforementioned A section) which performed all heat treatments from ** to **.
[0063] 2) By any type of SHIRIKOROI, a case depth can be made deep by adding Nb. Therefore, what is necessary is just to use the steel which contains Nb as material steel for the parts for which a thick hardening layer is needed. Since a case depth is dependent also on the aging-treatment time of **, its use of Nb content steel is advantageous to shorten the time and raise productivity.
[0064] Although these are the examples of an examination of the aforementioned case 1, the almost same result is obtained also in the example of an examination of a case 2. However, by the examination of a case 2, it carries out by the usual method of heating the whole and quenching, and the solution treatment of ** is a radio frequency heating method only about a required mosquito place (A section) in heat treatment of **. It carried out by the method of heating at 480 degrees C.
[0065] According to the heat treatment method of this invention the above-mentioned passage, even if it is one part, it is possible to give a locally different property by whether heat treatment of whether ** is heat-treated and ** is performed.
[0066] As the hard facing method of steel parts, a carburization hardening process, nitriding, etc. are common knowledge. Although these methods are suitable for the hard facing of an entire component, using for the local hard facing of parts is difficult methods. Moreover, with a carburization hardening process, since heating at high temperature and quenching are required, deformation of parts is caused, and there is also a difficulty that processing takes a long time, by nitriding. On the other hand, although hardening performs solution treatment of ** or ** only to a required portion by this invention method, the heating can be easily carried out by the radio frequency heating method etc. And since the parts after this solution treatment are not yet hardened, they are easy to finish-machine with machining. Subsequent aging treatment Since it is carried out at the low temperature 400-600 **, deformation of parts hardly becomes a problem.

[Translation done.]

EXAMPLE

[Example] Six kinds of steel shown in the above-mentioned table 1 is used, and it is absolute-size size. (diameter of about 80mm) The valve rod of the relief valve of a pump was produced and it processed by the heat treatment method of this invention. It is drawing 6 about the appearance and the boundary dimension of a valve rod. It is shown in (a). This valve rod is for the pressure inside a pump not exceeding constant value. It is the structure which will fall if a valve rod will go up, an internal pressure will be missed if the pressure inside a pump exceeds a critical value, and a pressure declines, and is settled in a valve seat. Therefore, while the tough nature which bears the shock when colliding with a valve seat is required for a valve rod, the abrasion resistance (high degree of hardness) excellent in a point and the sliding section is required.
[0068] Heat treatment conditions and the test condition are as follows.
[0069] [heat treatment
** Valve rod whole It is 180 at 950 degrees C. Water cooling is carried out after part-heating. subsequently -- 650 degrees C the A section (sliding section) and the C section (point) of a temper processing ** valve rod which heat for 180 minutes and carry out air cooling -- high-frequency induction heating -- coil feed rate it is the solution treatment which heats and carries out water cooling to 1050 degrees C by 1.5 mm/sec -- this high-frequency induction heating -- frequency: -- it carried out by 30kHz and electric capacity:150 KW, and the water jet from the jacket prepared immediately after the coil performed cooling
[0070] ** Valve rod whole At 480 degrees C Aging treatment heated for 180 minutes.
[0071] [an impact test and a tension test] -- the A section of a valve rod (portion to which all heat treatments of the above-mentioned ** - ** were performed) And the B section (portion to which heat treatment of the above-mentioned ** is not performed) A center to piece of a Charpy impact test (JIS No. 4) Test piece for tensile test (JIS No. 8) it extracts -- the impact test in 25 ** and the tension test in a room temperature were performed
[0072] [Measurement of a hardness test-case depth] The disk-like test piece was extracted from the A section and the B section of a valve rod right-angled to the medial axis, and the degree-of-hardness distribution from a front face was measured. The C section (point) If attached, only the degree-of-hardness distribution of the surface section was measured. These measurement results are indicated to be Table 4 to drawing 7 -9.
[0073]
[Table 4]
表 4

鋼種	タイプⅠ		タイプⅠ－Nb		タイプⅡ		タイプⅡ－Nb		タイプⅢ		タイプⅢ－Nb	
機械的性質	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部	A部	B部
引張強度 (kgf/mm²)	143	100	137	105	150	110	149	109	170	117	171	116
0.2%耐力 (kgf/mm²)	108	85	99	93	111	101	116	102	132	105	126	103
伸び (%)	20	26	14	21	16	24	13	26	9	18	8	16
衝撃値(kgf-m/cm²)	12	18	13	17	14	22	13	20	15	23	14	24
最大硬度 (HS)	67	38	69	40	69	41	71	43	73	44	74	46
硬化深度 (mm)	2	0	4	0	2	0	4.7	0	2.2	0	4.5	0
C部最大硬度 (HS)	68		68		71		72		74		75	
C部硬化深度 (mm)	1.8		3.6		1.9		4.2		2		4.4	

[0074] A hardening layer is formed, and although the hardening layer thickness (case depth) contains Nb, in every steel type from Type I to III, the direction is large [layer thickness] in the A section which performed all heat treatments from ** to **, so that clearly from drawing 7 - drawing 9 . That is, even if it is heat treatment on the same conditions, in the valve rod of this invention steel containing Nb, a hard facing layer becomes deep. When in other words obtaining the hardening layer of the same depth, the direction of steel RO can be managed with a short-time aging treatment.
[0075] the B section (namely, portion which has not performed solution treatment of **) **** -- a hardening layer does not exist It is clear from this that it is possible to establish the field which is locally rich in abrasion resistance by the high degree of hardness in the position of parts. And as shown in Table 4, since the core part of parts is tough in every portion, the shock resistance of parts is also fully secured.
[0076] The maximum degree of hardness and case depth of the C section which were appended to Table 4 are almost the same as the A section. That is, a valve rod point has a high degree of hardness, and is excellent in abrasion resistance. Although the mechanical property of the core part of the C section is not measured, it is clear to have the same property as the A section, and a core part can be presumed to be what is rich in tough nature.
[0077] In the above-mentioned example, after heat treatment of **, screw cutter processing of the B section of a valve rod was performed, before heat-treating ** in the A section and the C section. However, since ** is not heat-treated as mentioned above in the B section, the surface section is hardly hardened to the last, either. Therefore, after all heat treatments of the whole valve rod are completed, you may perform screw cutter processing. Few more distorted parts can be obtained by doing so.
[0078] The former and this kind of valve rod is JIS. SUS 630 Steel (precipitation hardening stainless steel) It is produced. this steel -- an aging treatment of after -- a degree of hardness -- at most -- It goes up only to about 50 HS. therefore, the building-up according to a Stellite in a valve rod nose of cam -- giving -- further -- Gas-nitriding processing which is called 60 hours at 500 degrees C was performed, and it was considering as the product. And the SUS 630 A steel valve rod is inferior to the valve rod produced by this invention method in an impact resistance value and elongation. Furthermore, the valve rod produced by this invention method has little distortion, and won also in the corrosion resistance and corrosion resistance in sea water to a sulfuric acid, a hydrochloric acid, etc.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing two kinds of cases of the heat treatment method of this invention collectively.
[Drawing 2] It is drawing showing the appearance of the test piece used for the examination of heat treatment.
[Drawing 3] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 1) which changed heat treatment conditions with the parts of Type I of SHIRIKOROI of this invention.
[Drawing 4] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 1) which changed heat treatment conditions with the parts of Type II of SHIRIKOROI of this invention.
[Drawing 5] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 1) which changed heat treatment conditions with the parts of Type III of SHIRIKOROI of this invention.
[Drawing 6] (a) The external view of the valve rod with which the examination of ******** was presented, and (b) It is the typical cross-section enlarged view of the C section.
[Drawing 7] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 4) which changed the heat treatment conditions of the valve rod (a material is Type I of SHIRIKOROI) of drawing 6 .
[Drawing 8] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 4) which changed the heat treatment conditions of the valve rod (a material is Type II of SHIRIKOROI) of drawing 6 .
[Drawing 9] It is the graph which shows the measurement result of the case depth of a portion (the A section and the B section of drawing 4) which changed the heat treatment conditions of the valve rod (a material is Type III of SHIRIKOROI) of drawing 6 .

[Translation done.]

* NOTICES *

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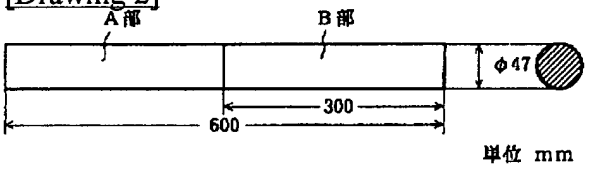
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]

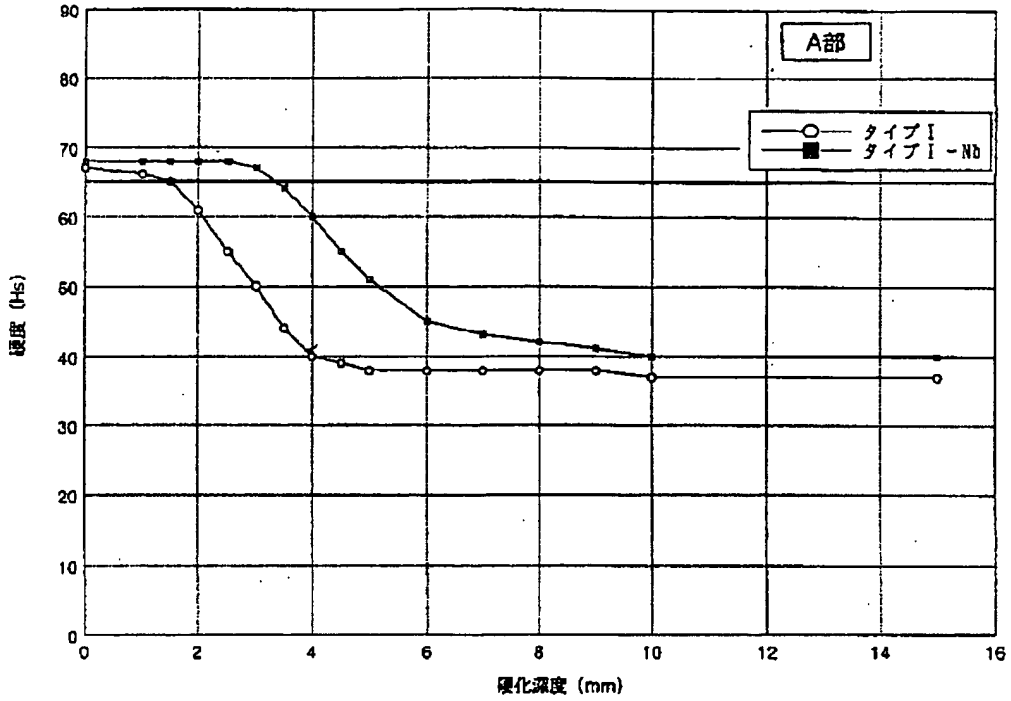
	部品の位置	①調質処理	②溶体化処理	③時効処理
ケース1	部品 A部（表層硬化部）	あり	あり	あり
	B部（表層非硬化部）	あり	（なし）	あり
ケース2	部品 A部（表層硬化部）	あり	あり	あり
	B部（表層非硬化部）	あり	あり	（なし）

[Drawing 2]



[Drawing 3]

(a)



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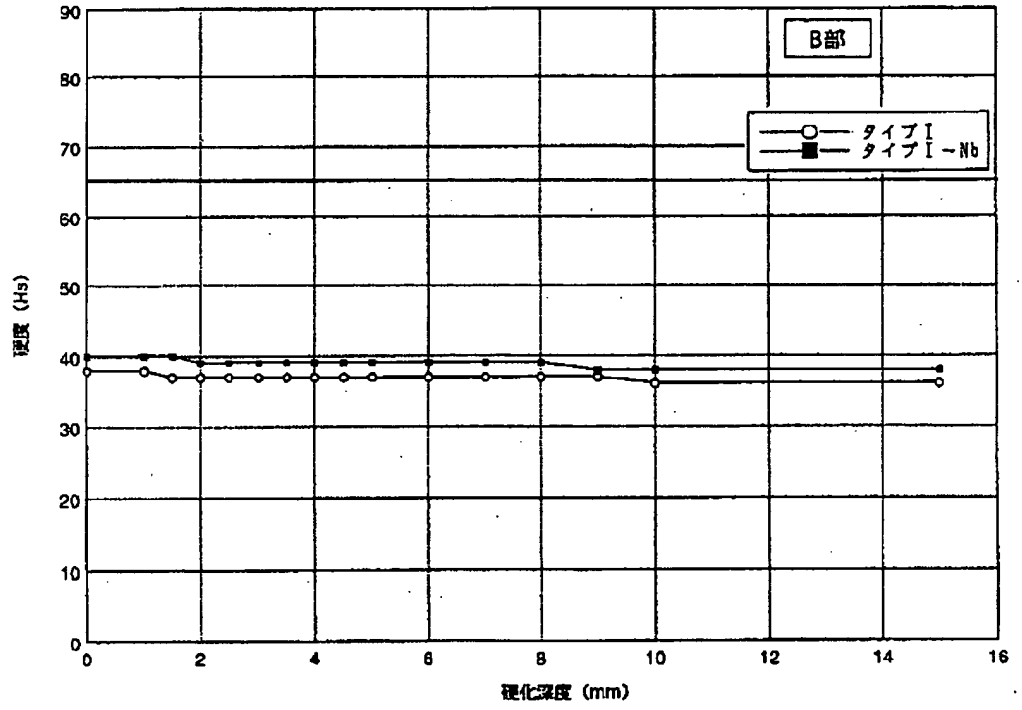
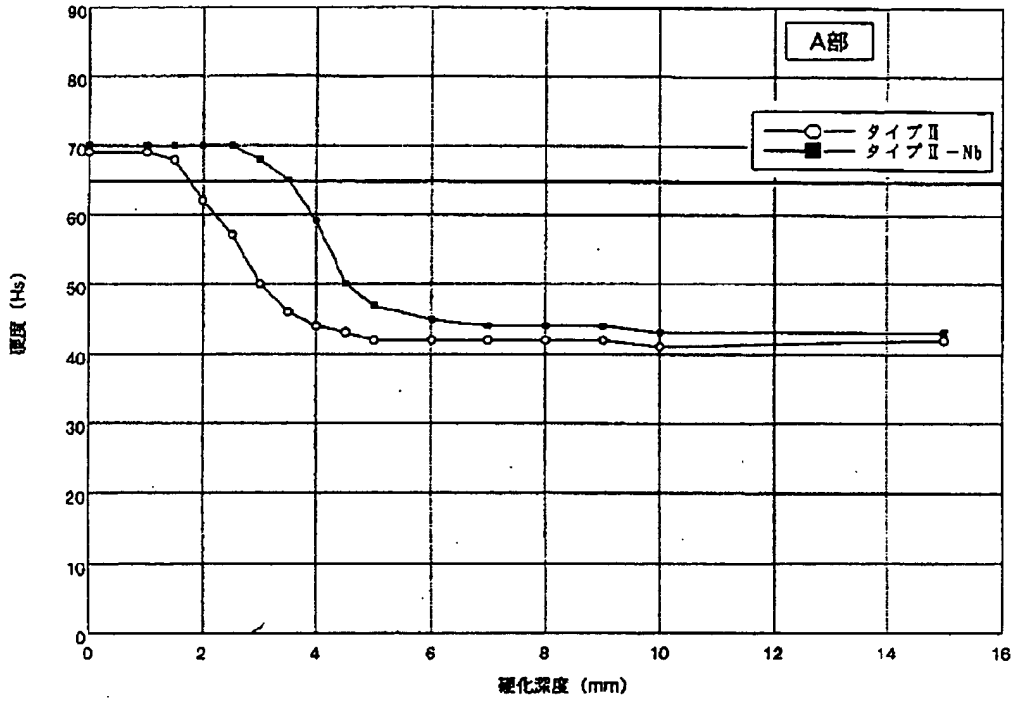
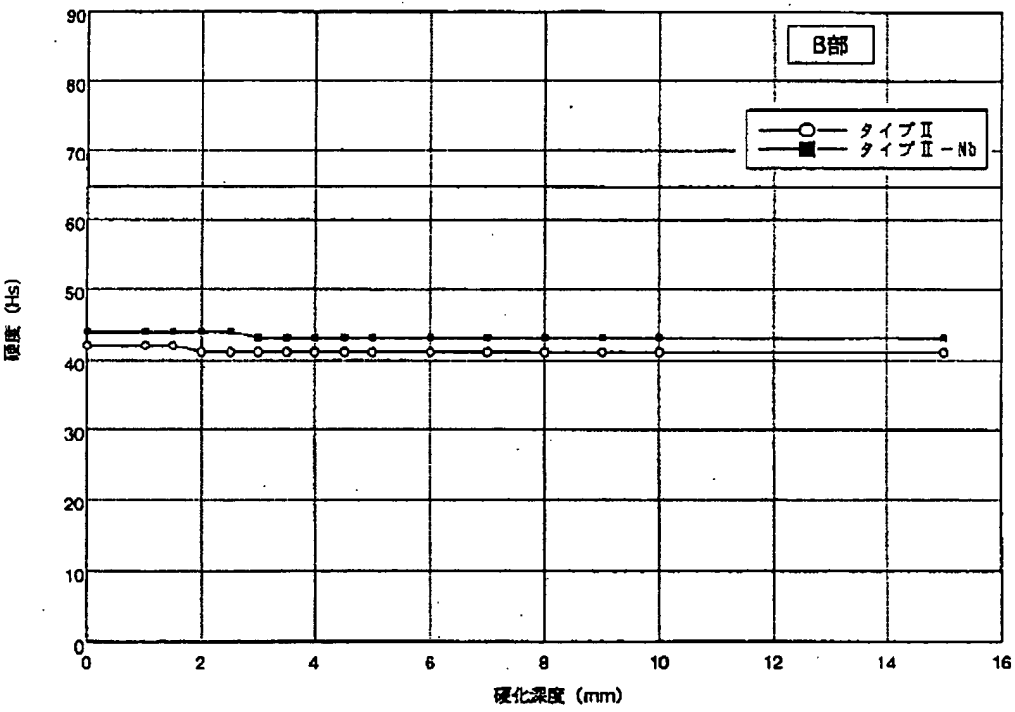


[Drawing 4]

(a)

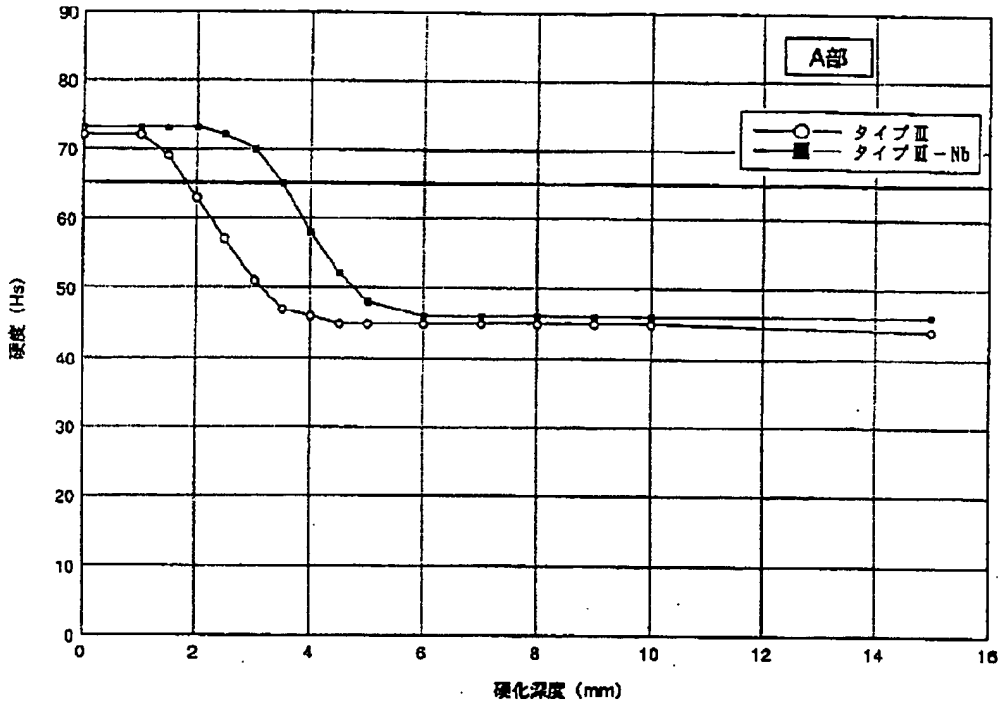

A部
タイプII
タイプII－Nb
硬度（Hs）
硬化深度（mm）
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16

(b)


B部
タイプII
タイプII－Nb
硬度（Hs）
硬化深度（mm）
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16

[Drawing 5]

(a)


A部
タイプⅢ
タイプⅢ－Nb
硬度（Hs）
硬化深度（mm）
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10
20
30
40
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70
80
90
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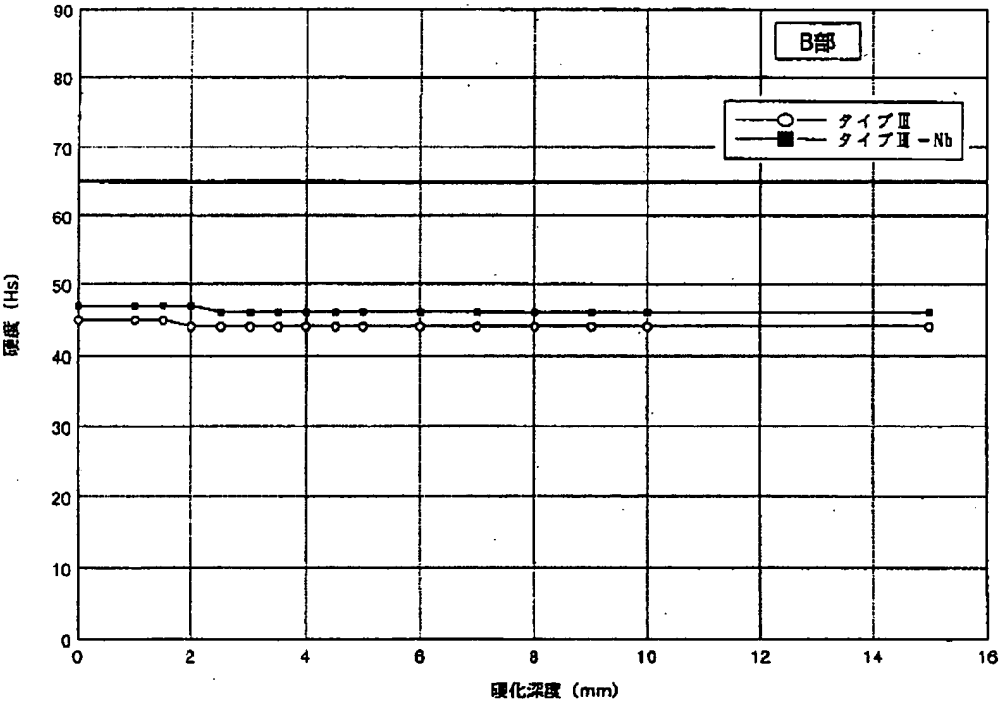
2
4
6
8
10
12
14
16

(b)


B部
タイプⅢ
タイプⅢ－Nb
硬度（Hs）
硬化深度（mm）
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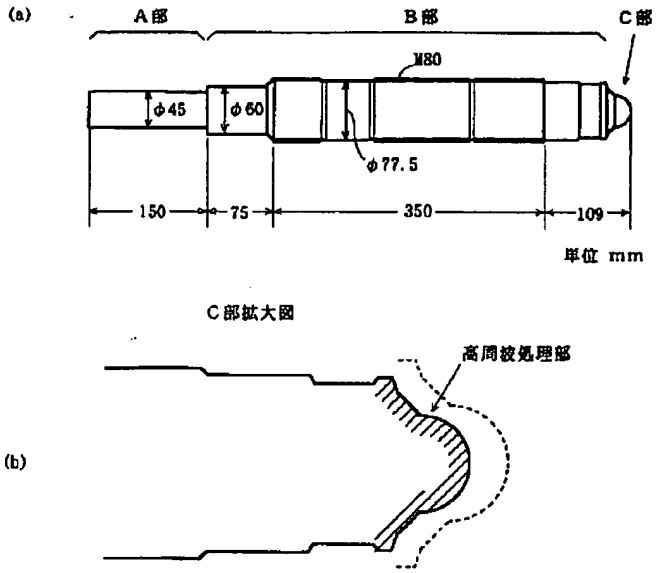
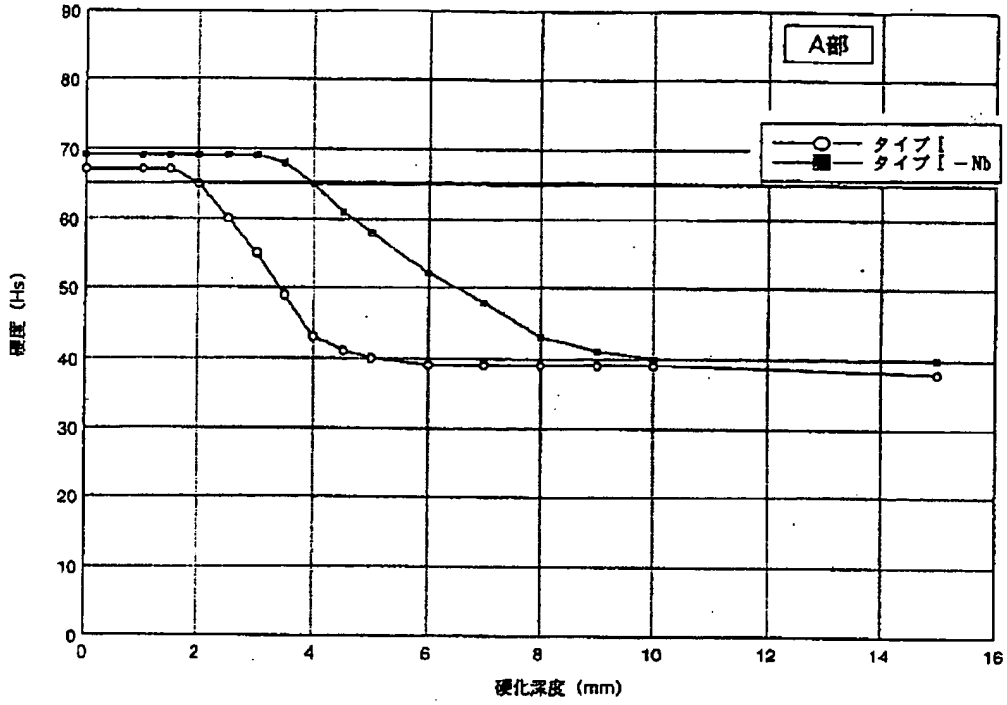
2
4
6
8
10
12
14
16

[Drawing 6]



[Drawing 7]

(a)


A部
タイプI
タイプI-Nb
硬度（Hs）
硬化深度（mm）
0
10
20
30
40
50
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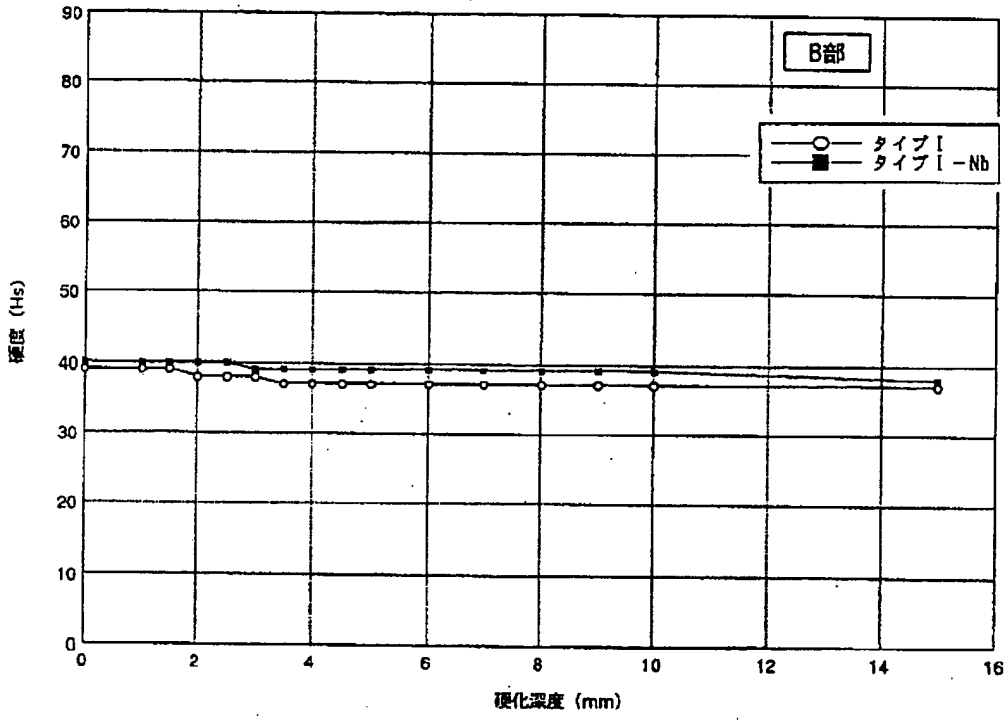
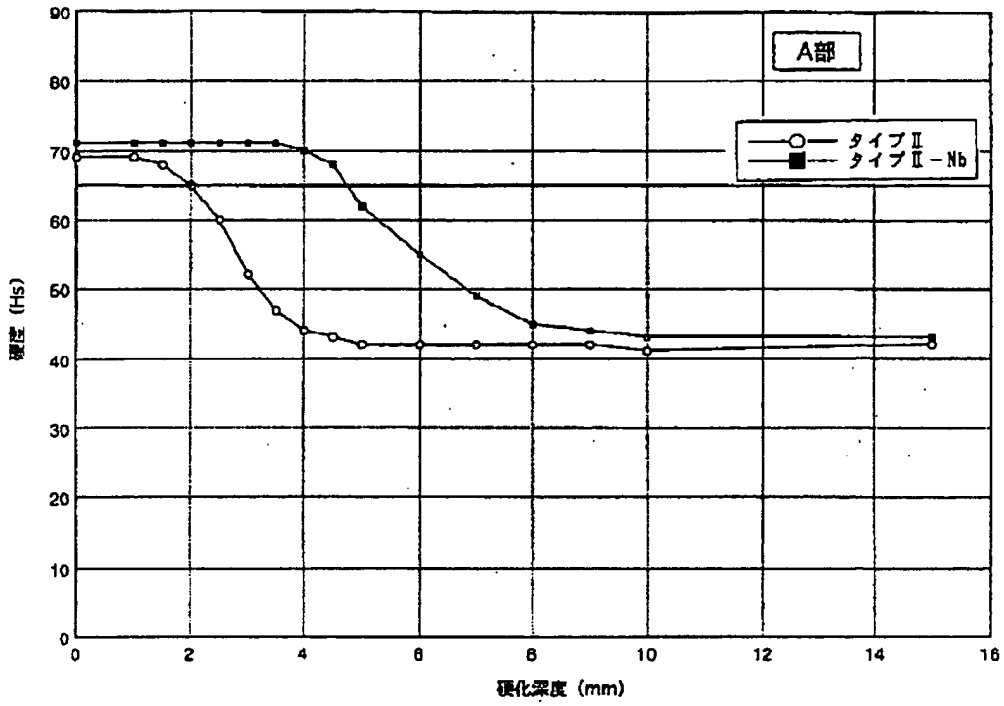
70
80
90
0
2
4
6
8
10
12
14
16

(b)


B部
タイプI
タイプI-Nb
硬度（Hs）
硬化深度（mm）
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16

[Drawing 8]

(a)



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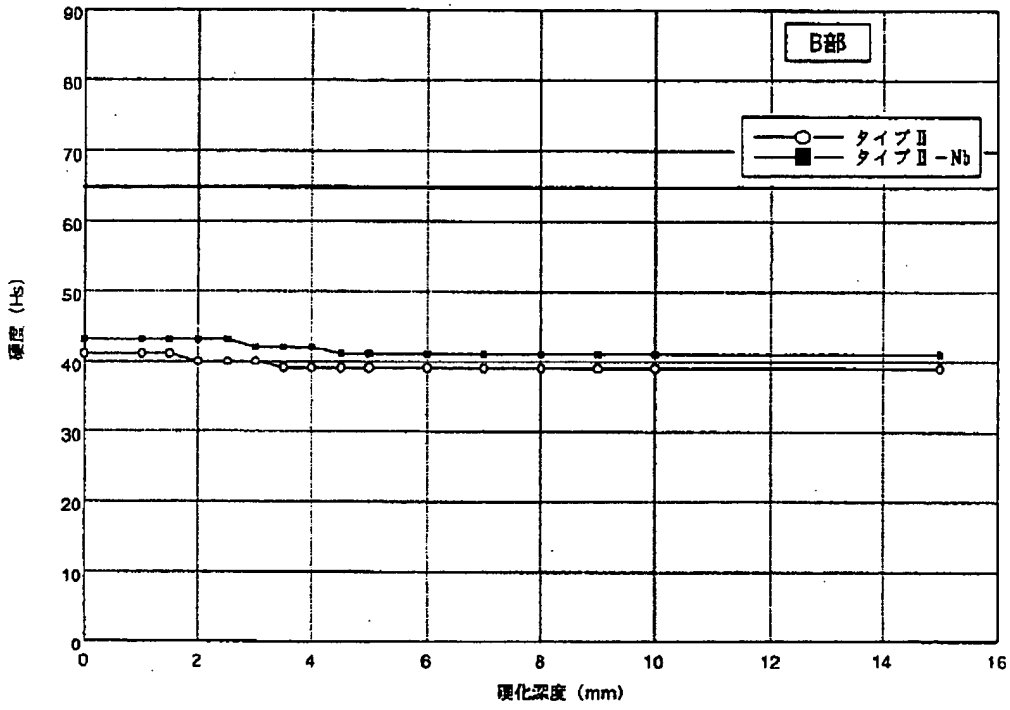
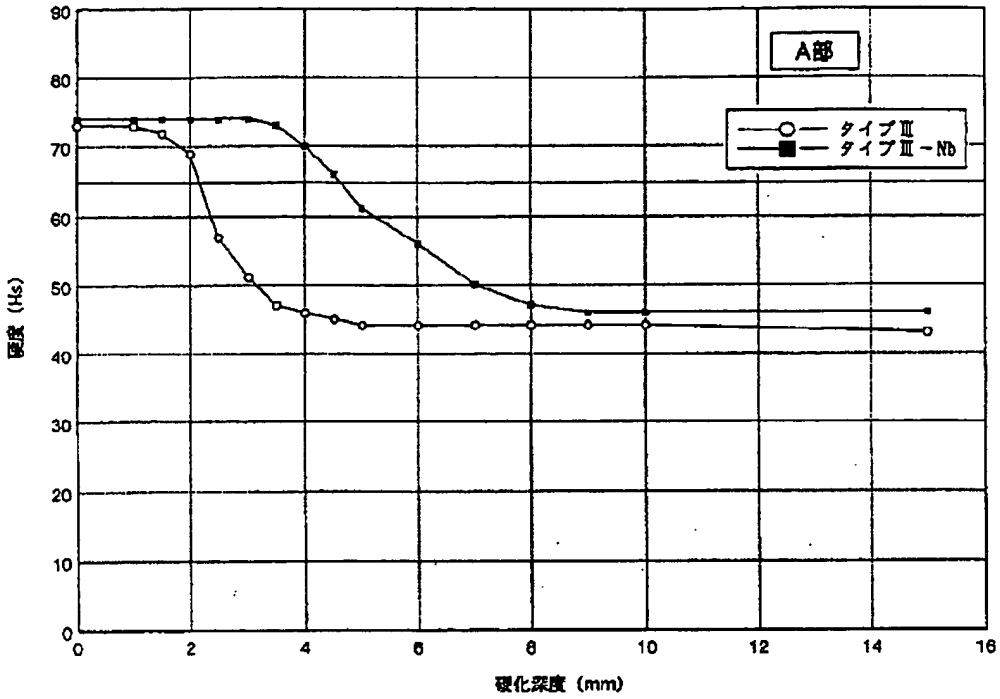
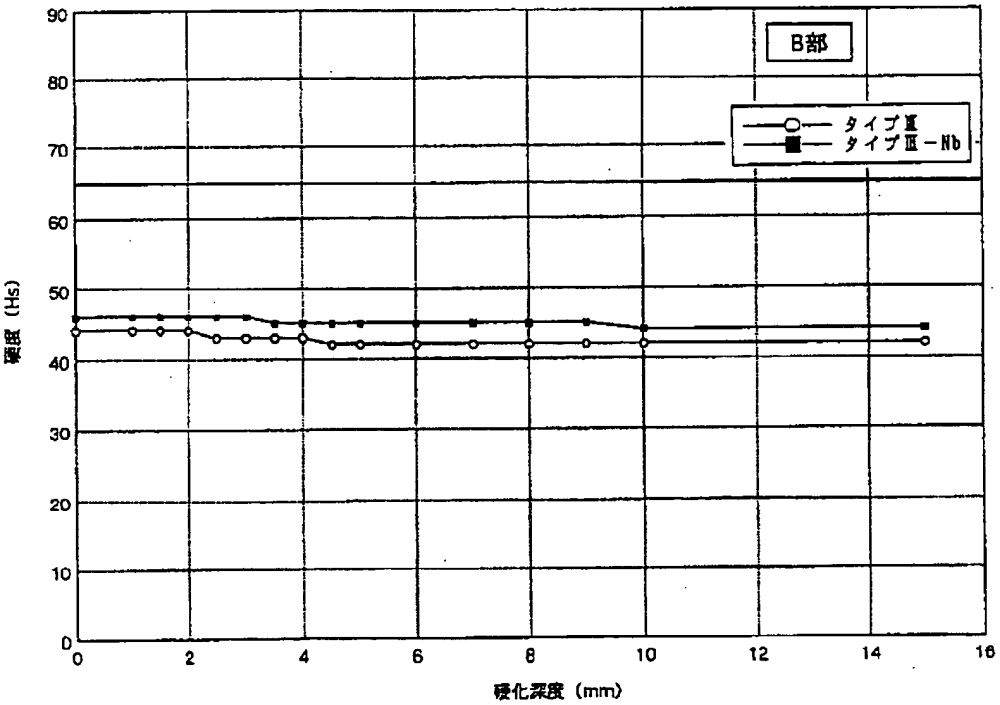


[Drawing 9]

(a)



(b)



[Translation done.]